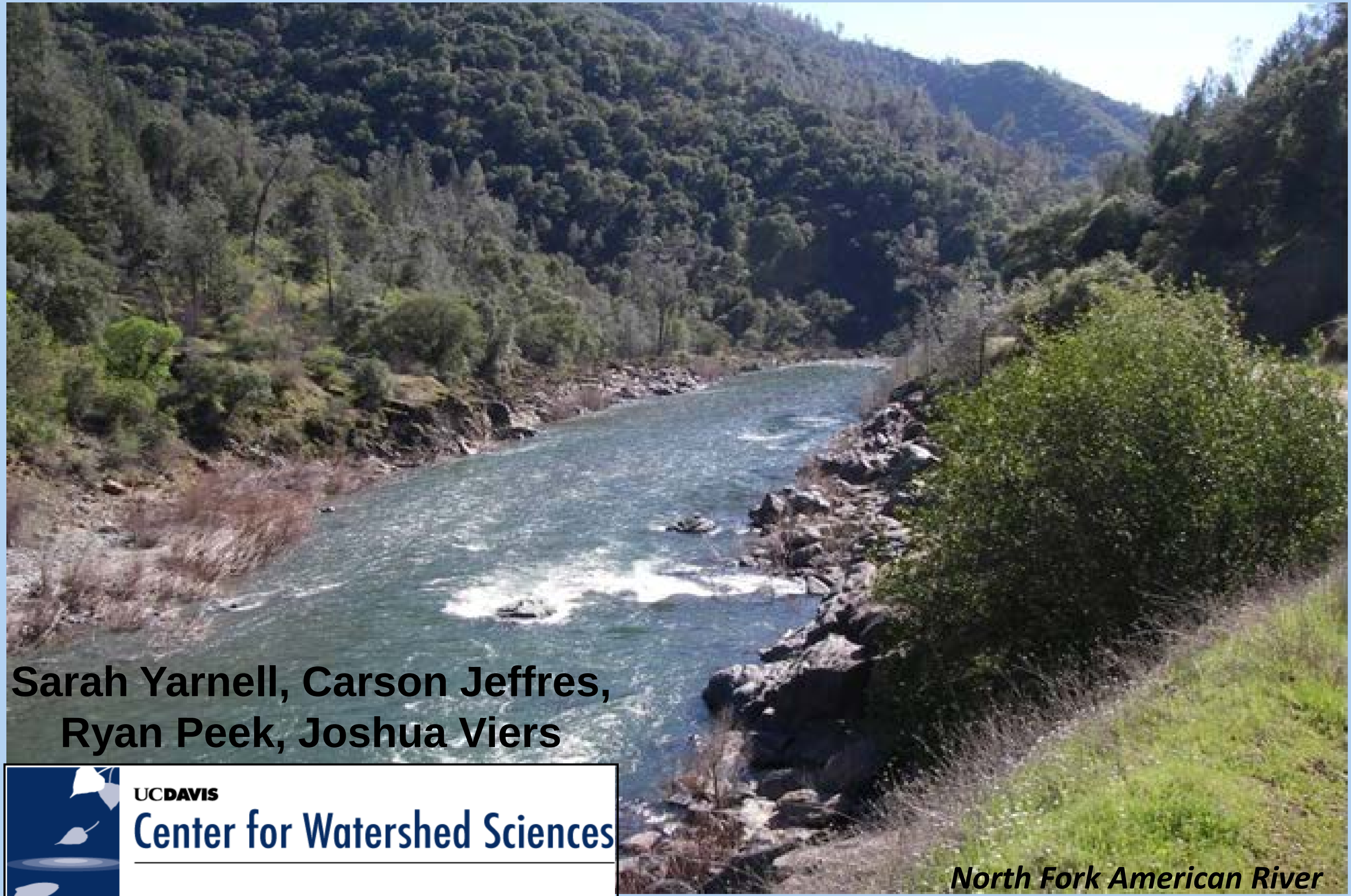
Ecological Response to the Unregulated Spring Flow Regime in California's Sierra Nevada

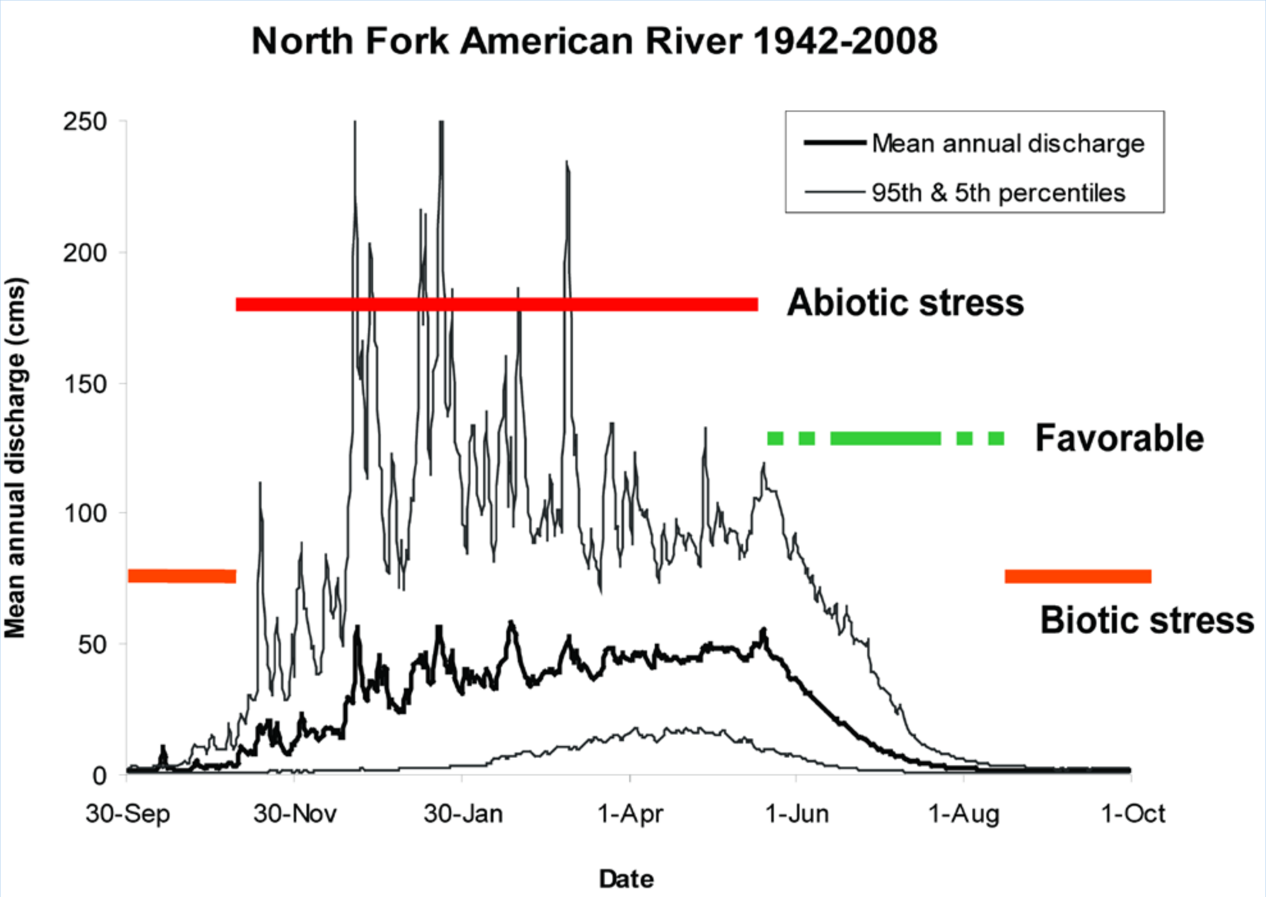


Sarah Yarnell, Carson Jeffres, Ryan Peek, Joshua Viers

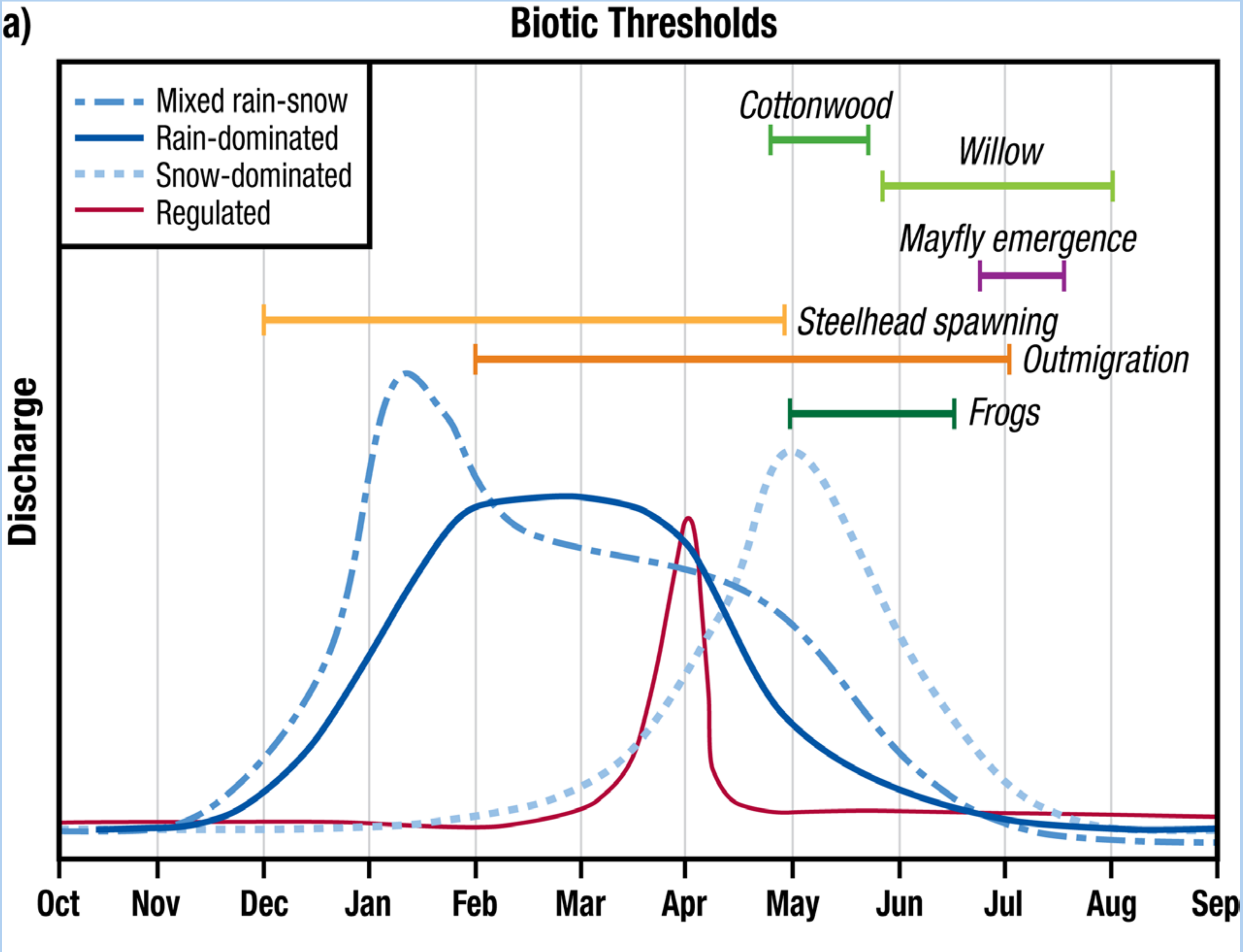
UC DAVIS Center for Watershed Sciences

Spring Snowmelt Recession Ecology

- The one time annually where high resources are coupled with predictable flows
- Results in high biodiversity (Gasith & Resh 1999)



Yarnell, S.M., J.H. Viers and J.F. Mount. 2010. BioScience 60:114-127.



Yarnell et al. 2010

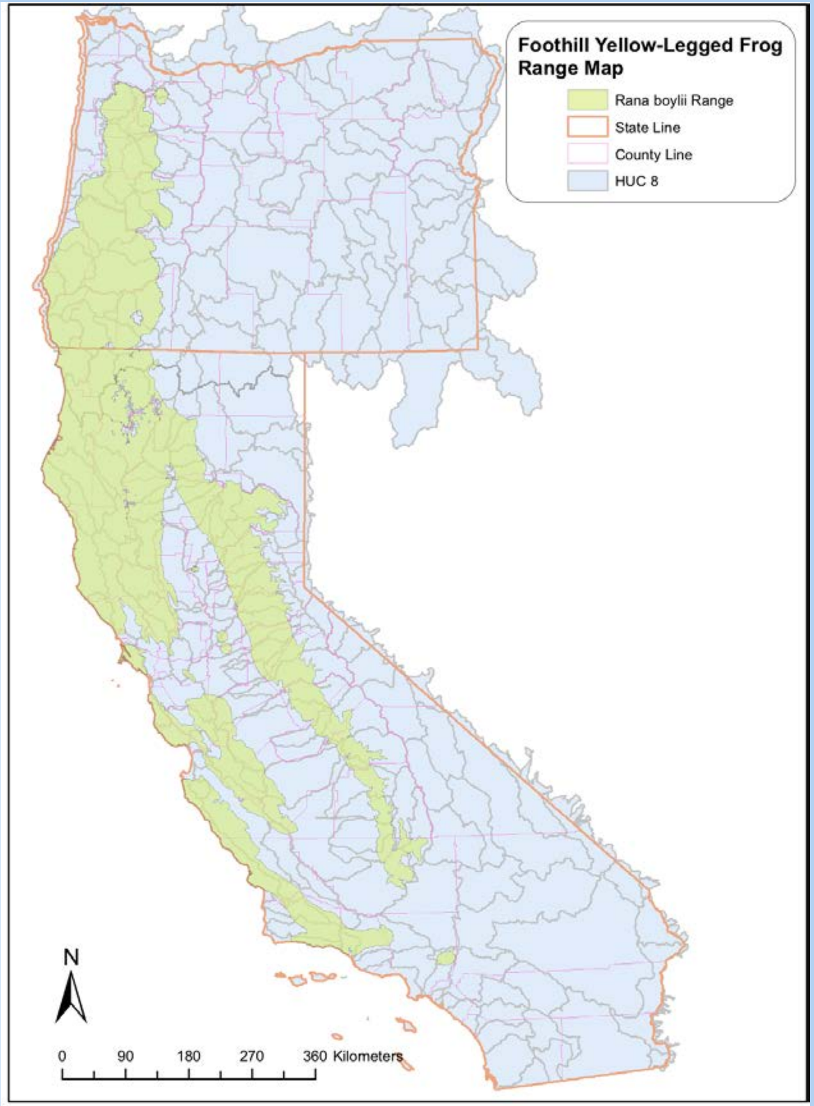
Foothill Yellow-legged Frog

- Extant in CA and OR for ~8 million years
(Macey et al. 2001)

- Species is an obligate stream breeder - uses riparian, river and tributary habitat (Twitty et al. 1967, Kupferberg 1996)

- Has disappeared from over 50% of its historic range
(Davidson et al. 2002, Lind 2005)

- California Species of Special Concern – requires consideration in management



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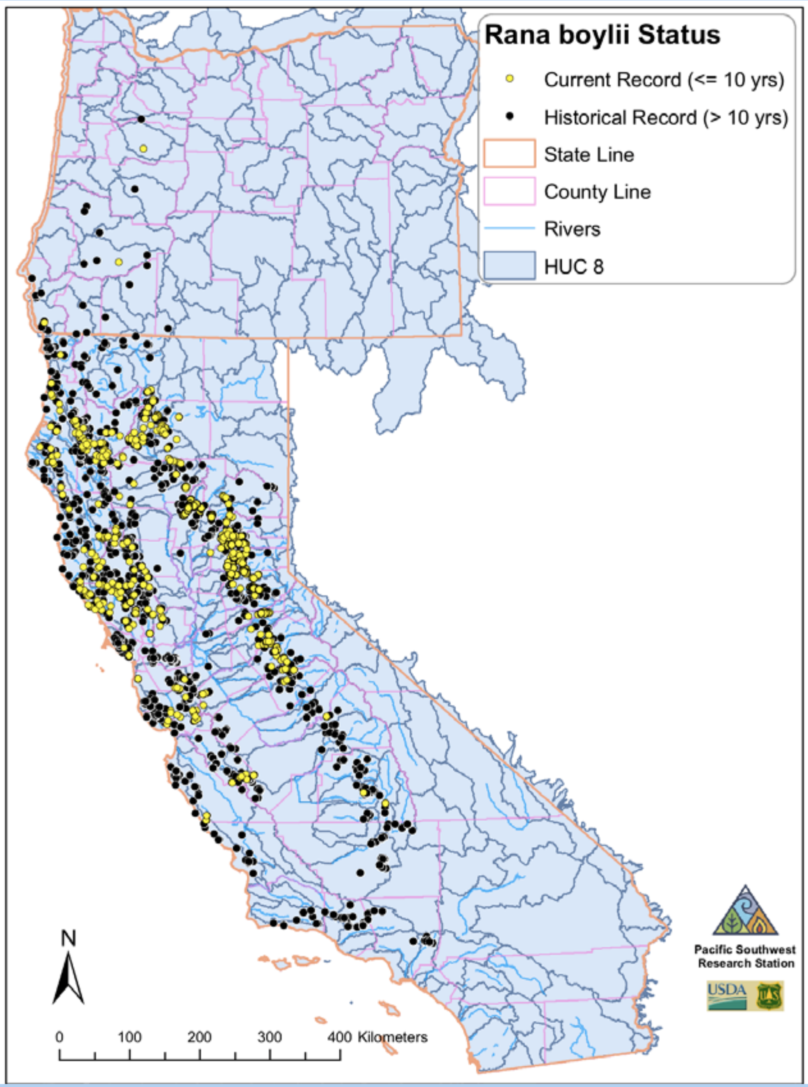
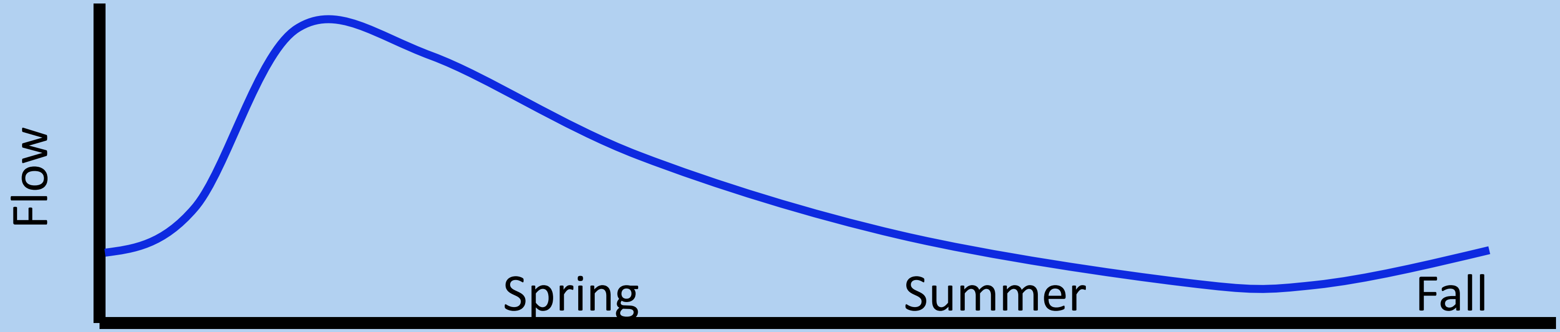
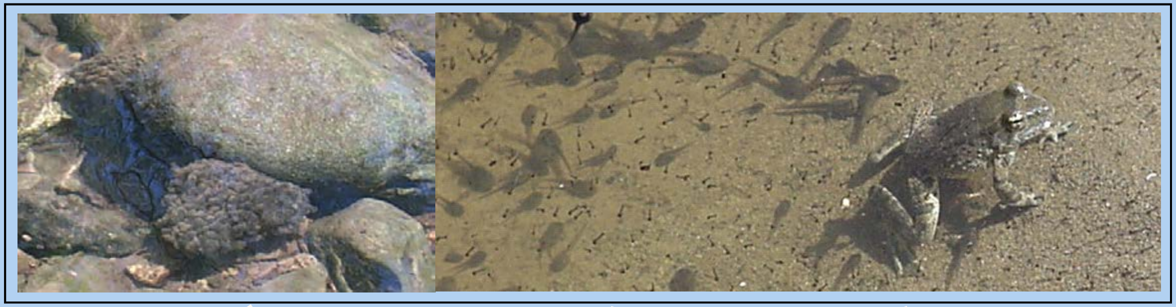


Foothill Yellow-legged Frog Life History in Synchrony with Predictable Flow Regimes



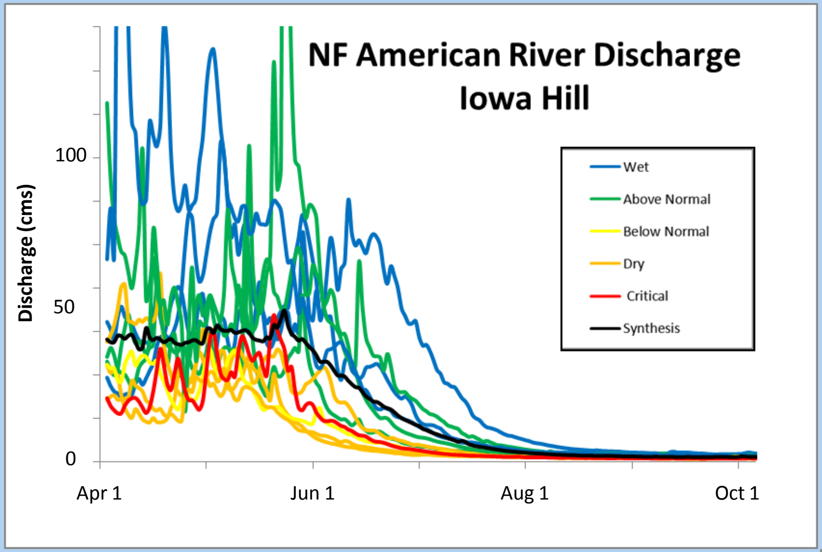


Eggmasses laid in sheltered locations with locally consistent depth and velocity

Tadpoles rear in stable low flow warm productive locations

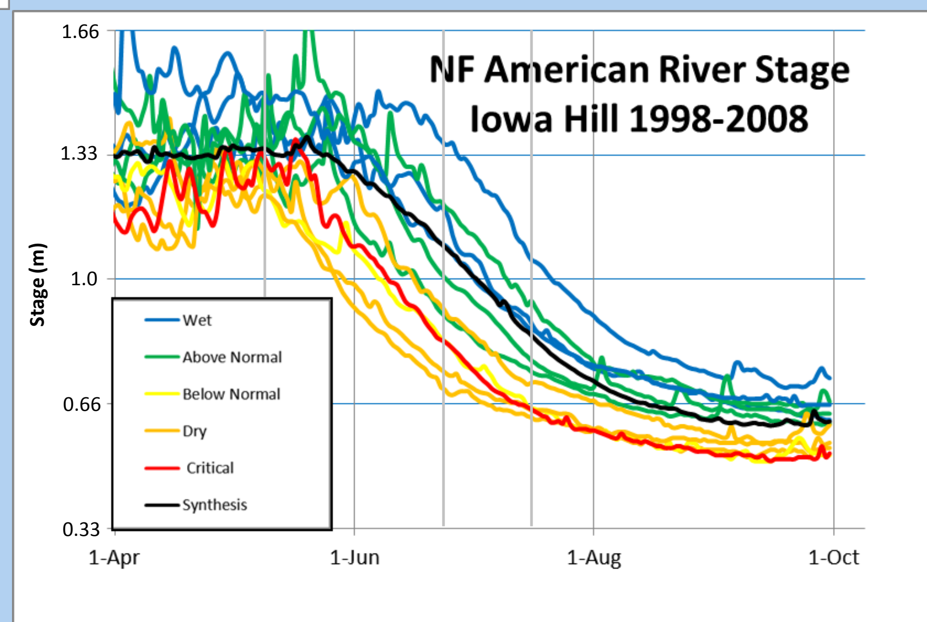
Tadpoles metamorphose and move to over-wintering refugia

Measured Discharge at NF American 1998-2008



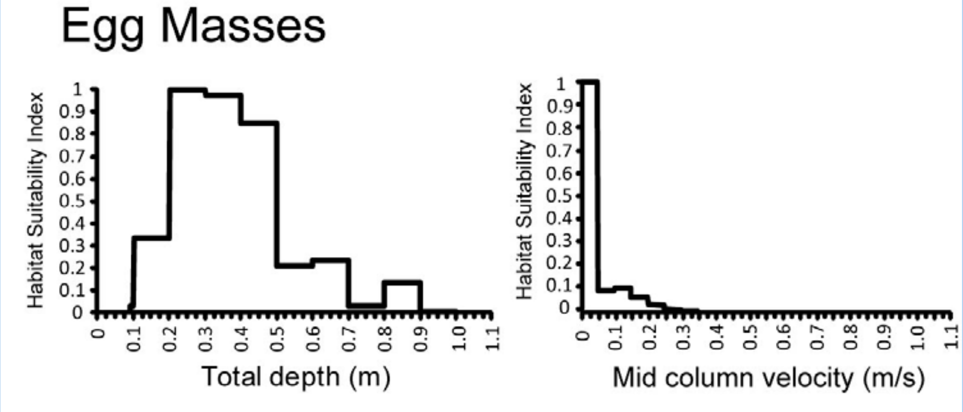
Measured *discharge* varies across water year types, but *stage* changes are consistent during the recession across all water year types due to consistent recession rates

At cross-sections in FYLF breeding habitat, recession rates are **less than** 10 cm per week in all water year types.



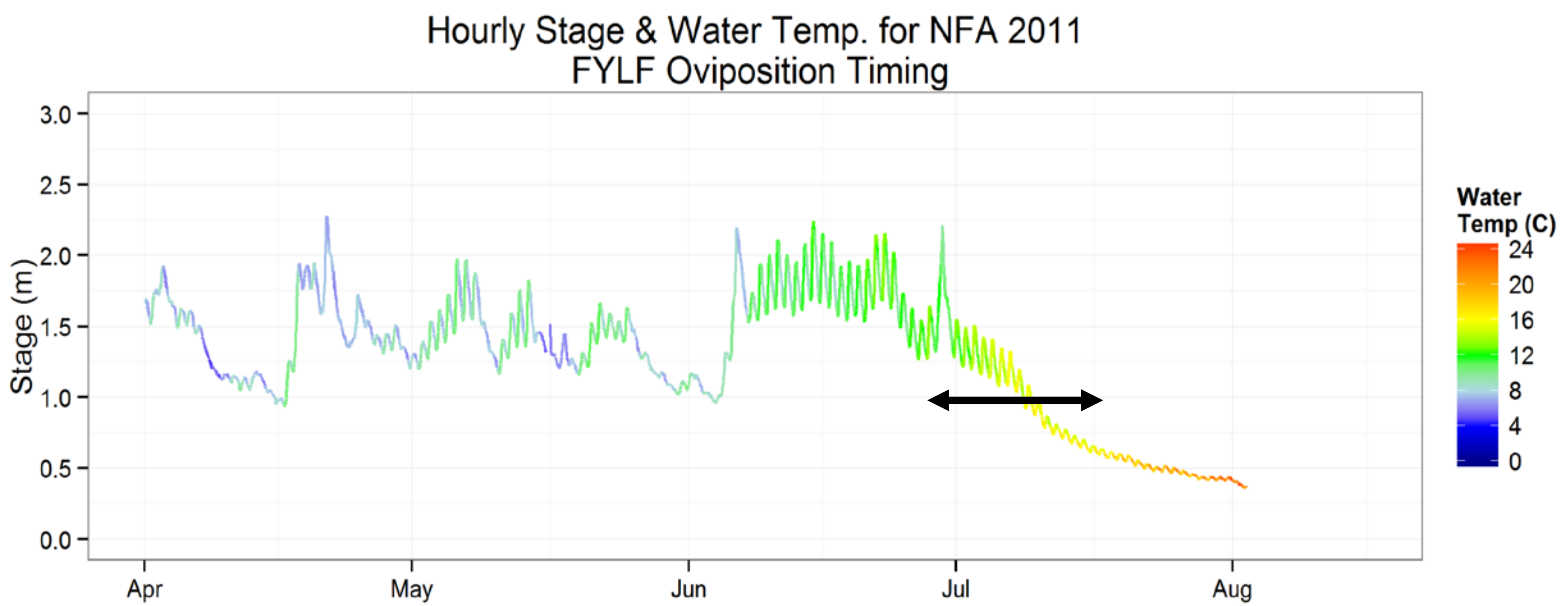
Foothill Yellow-legged Frog Breeding Habitat

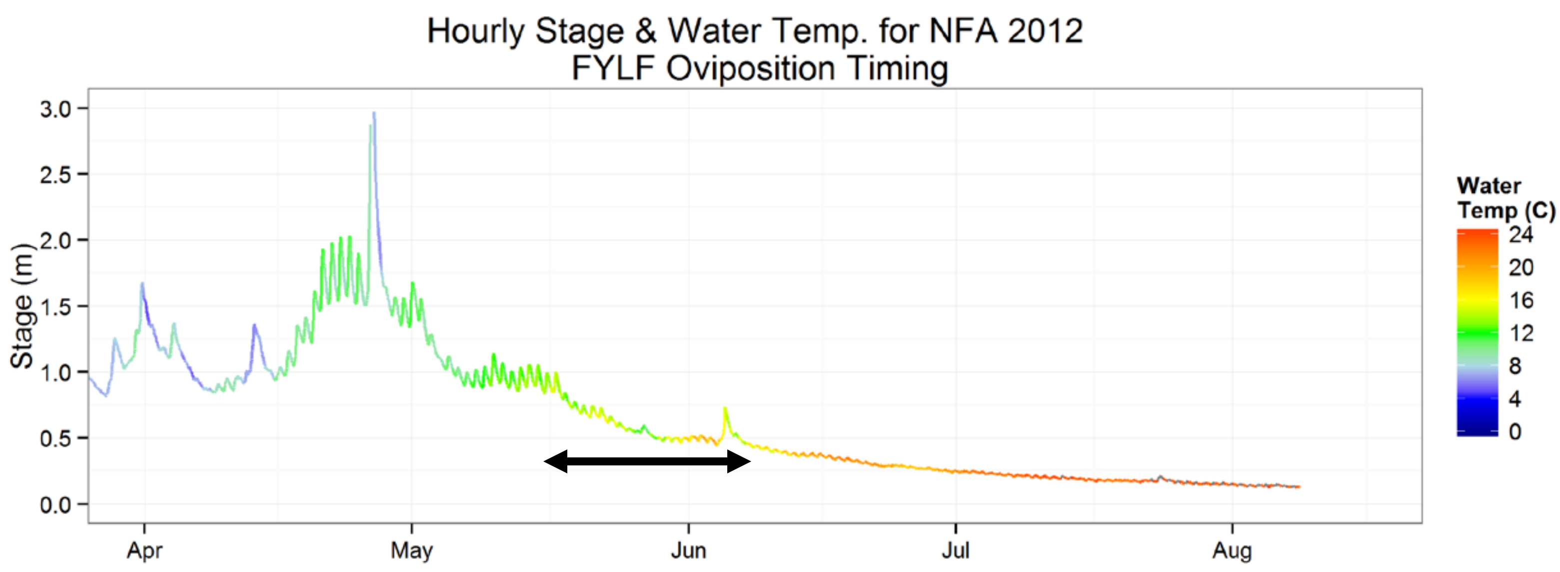
- Frogs lay eggmasses in very low velocity locations at 20-40cm depth
- 3 weeks required for eggmasses to hatch and tadpoles to grow big enough to follow receding water's edge
- Eggmasses can be scoured by large increases in flow and desiccated by fast recession rates



(Bondi C.B., S.M. Yarnell and A.J. Lind. 2012. Herpetological Conservation and Biology, in press)

Plasticity in Breeding Timing





Cosumnes River Floodplain

- Lower elevation basin at edge of valley floor with restored floodplain
- Unregulated mixed rain-snow system with recession ending in late May (smaller snowpack)
- Native spring spawners and juvenile salmonids utilize vegetated floodplain habitat

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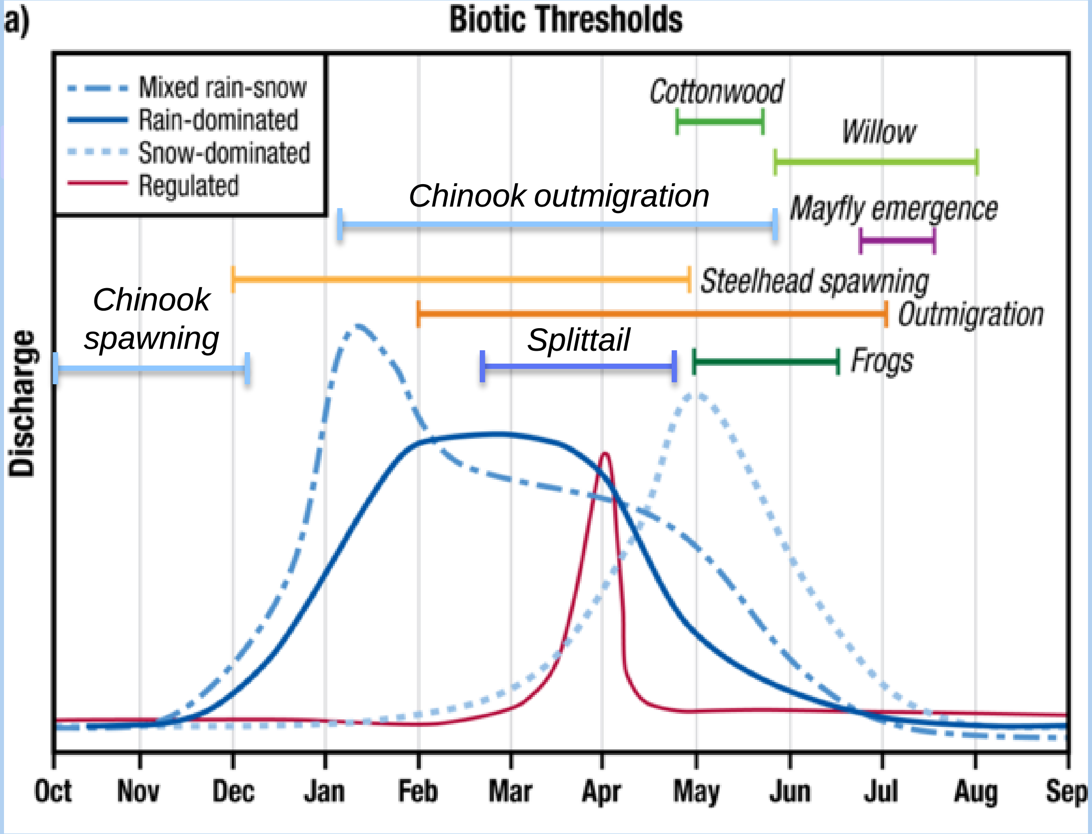
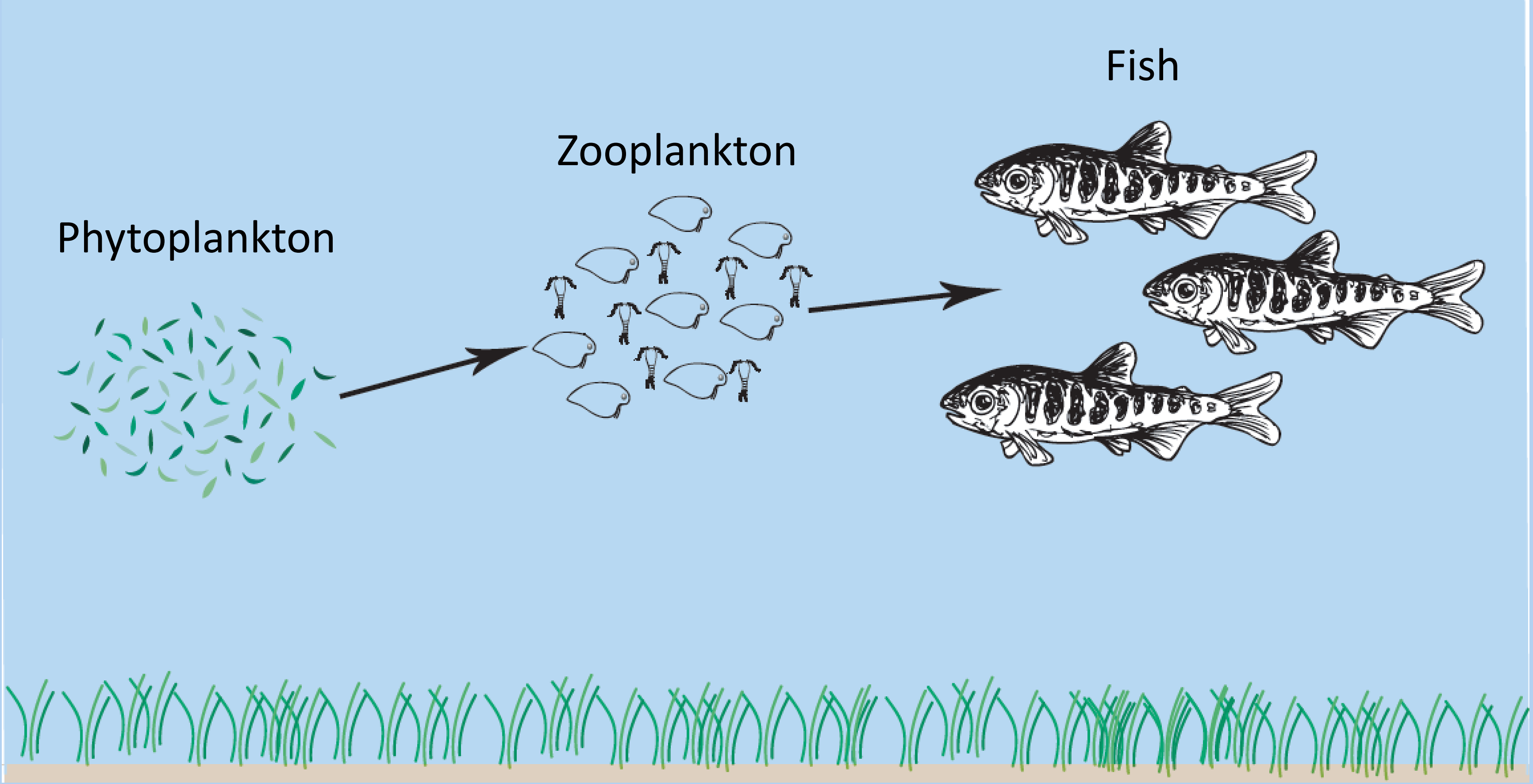
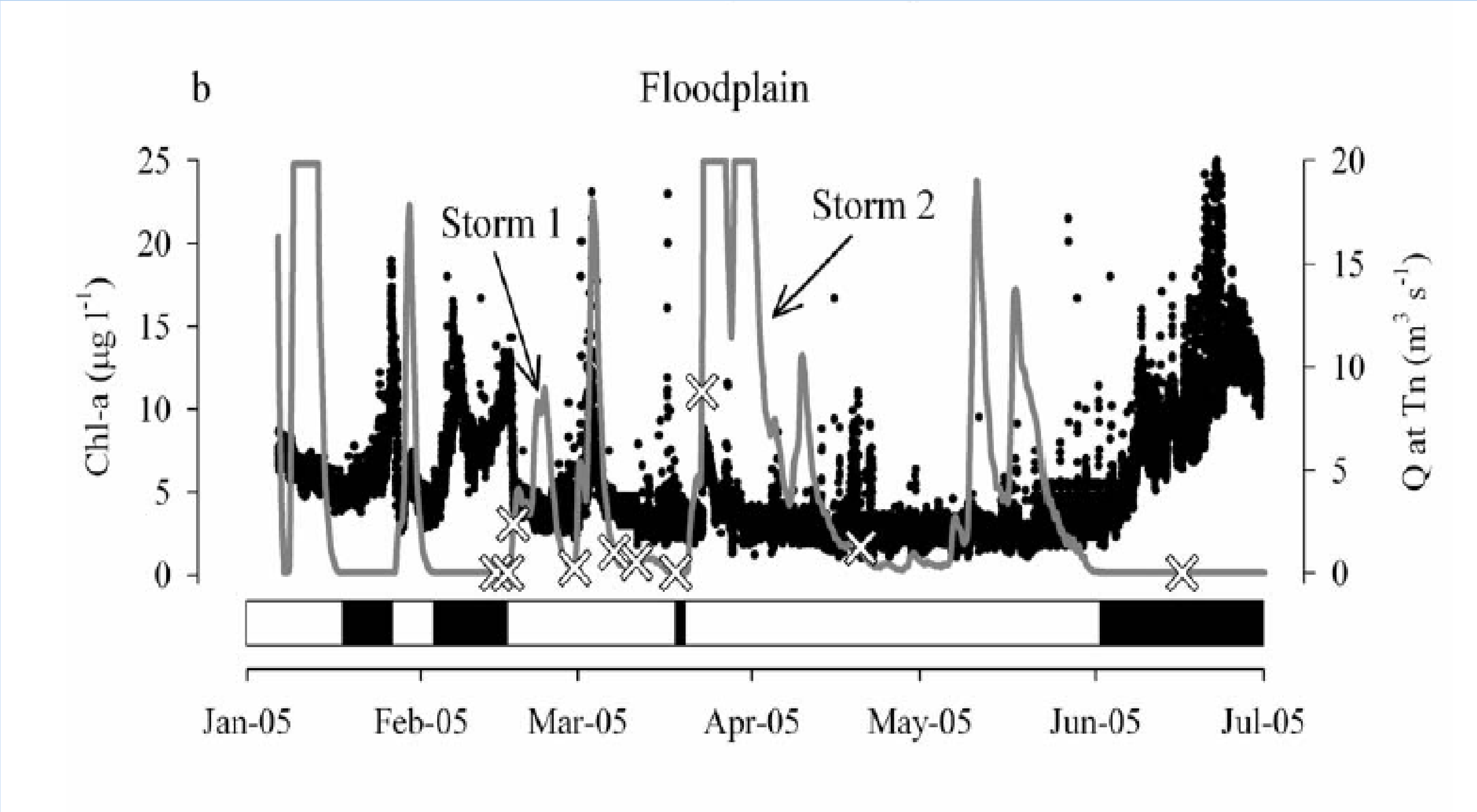


Floodplain Food Web

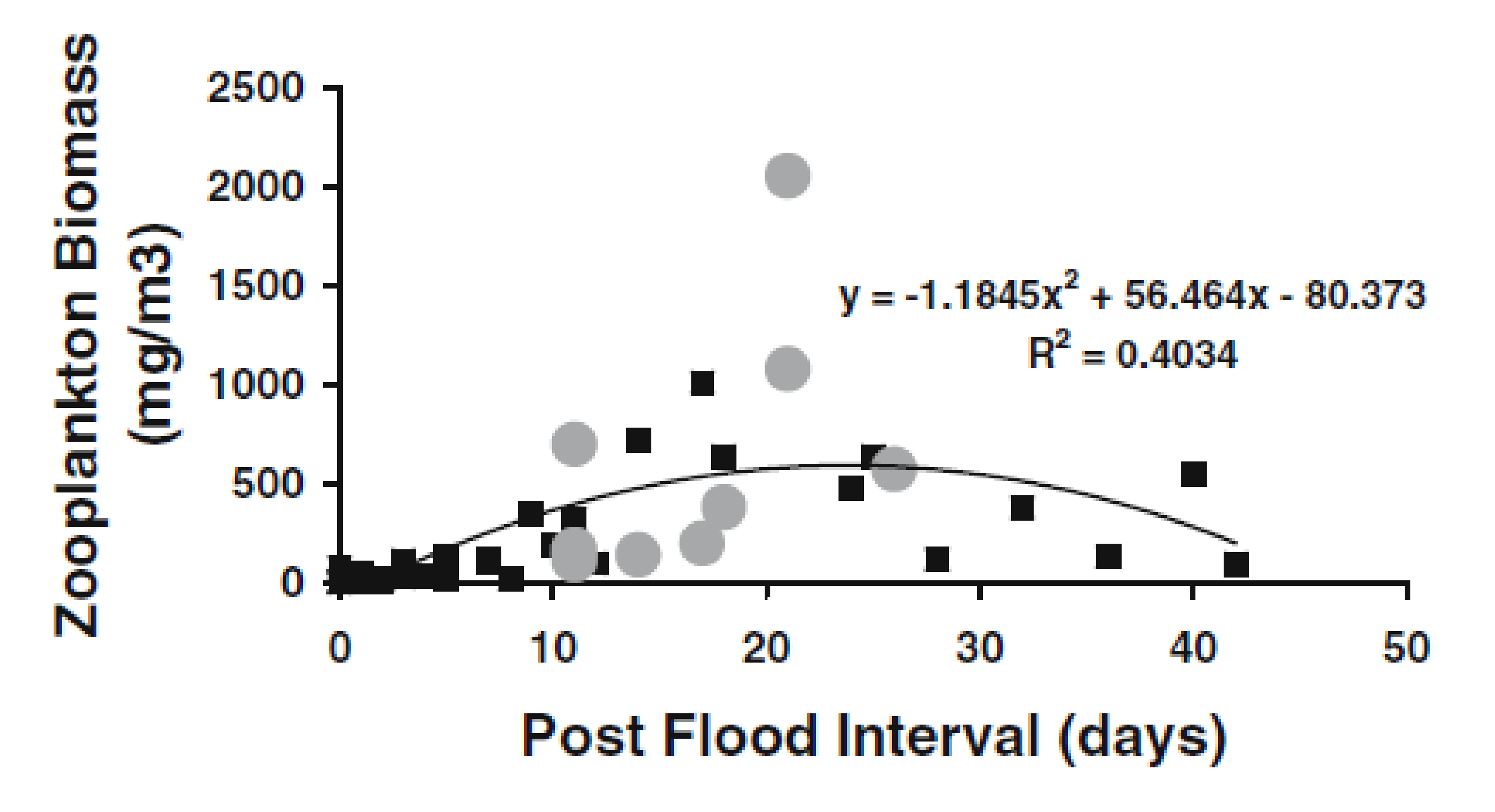


Chlorophyll-a Biomass



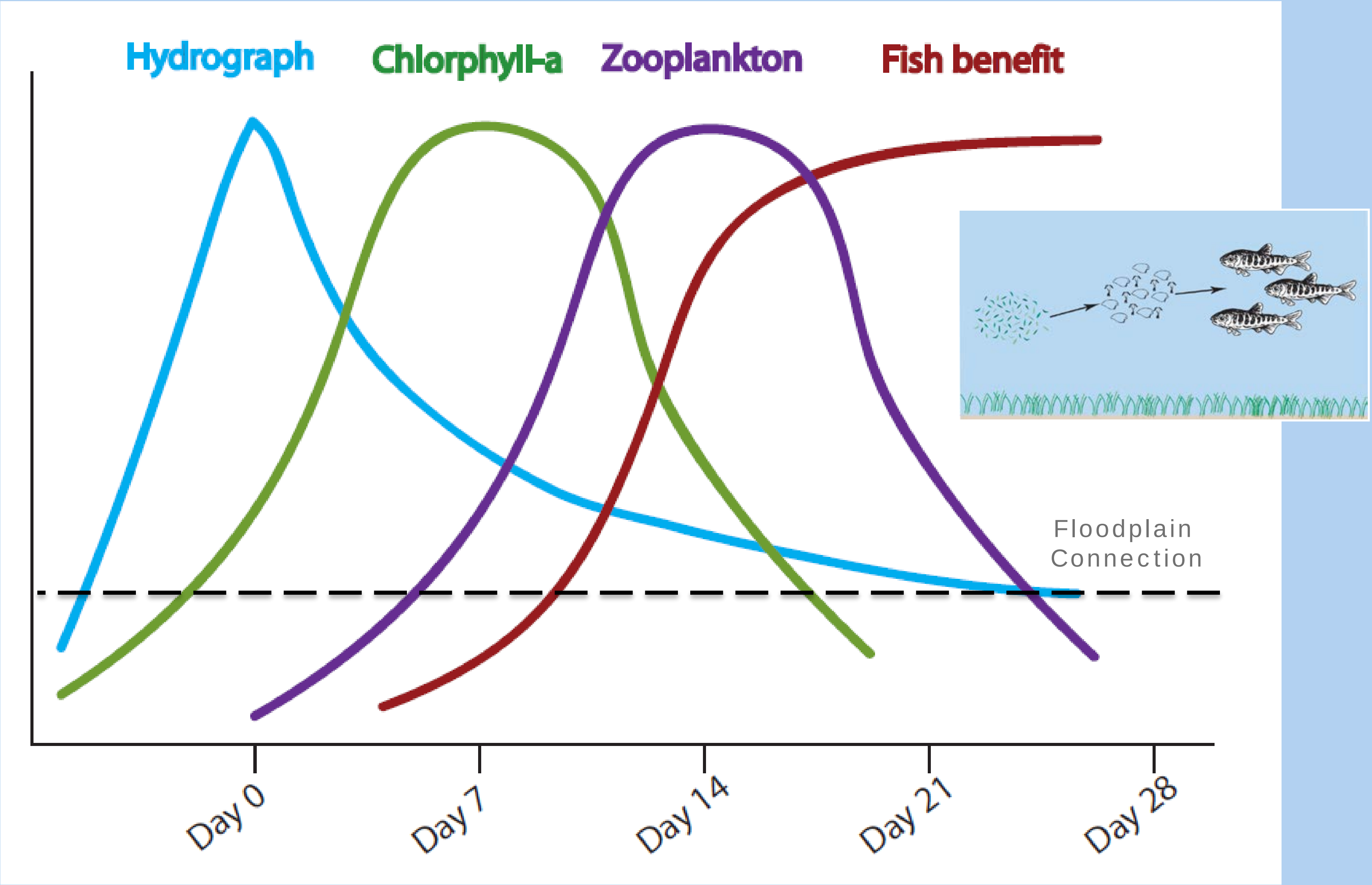
(Ahearn et al. 2006)

Zooplankton Biomass

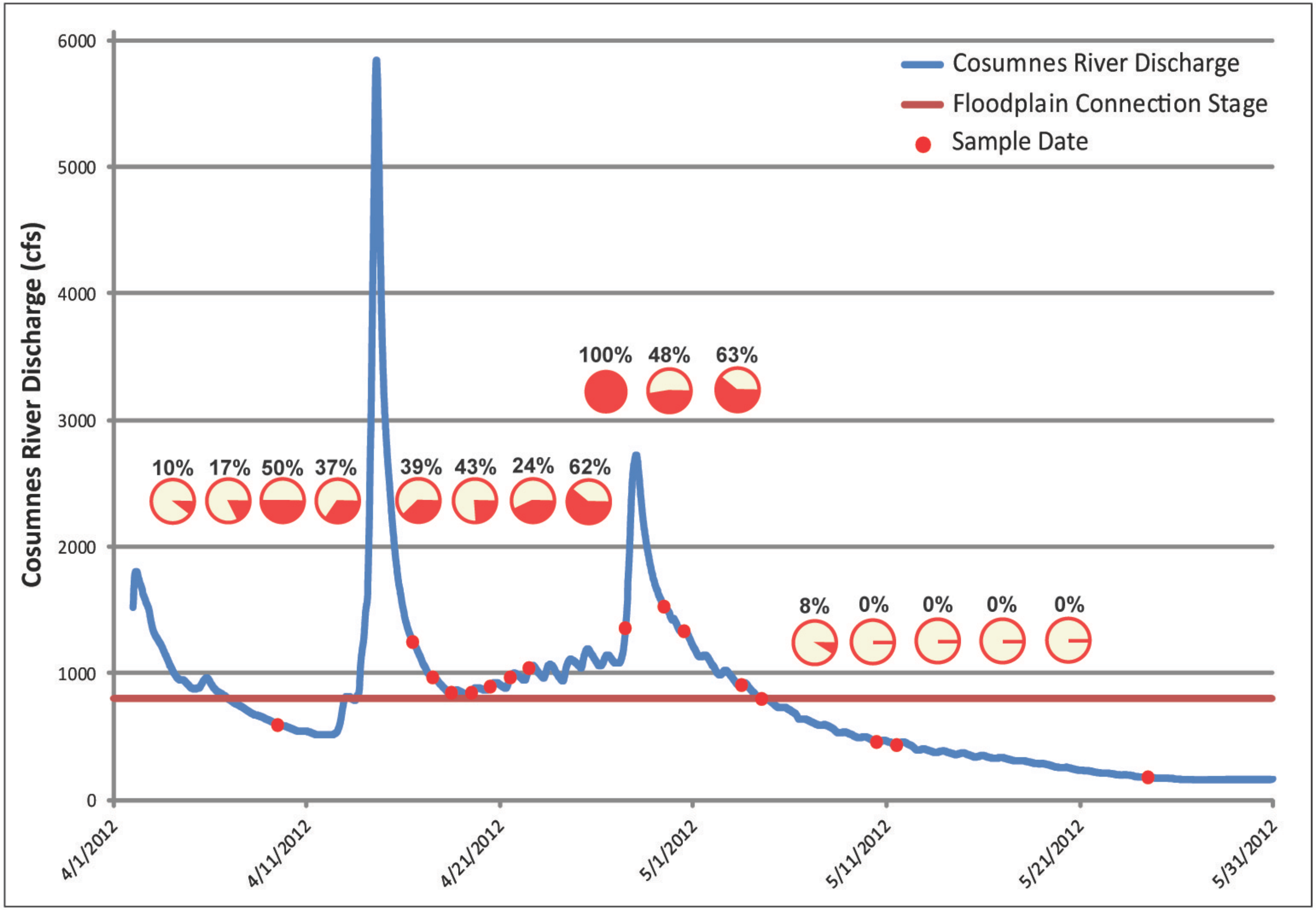


(Grosholz and Gallo, 2006)

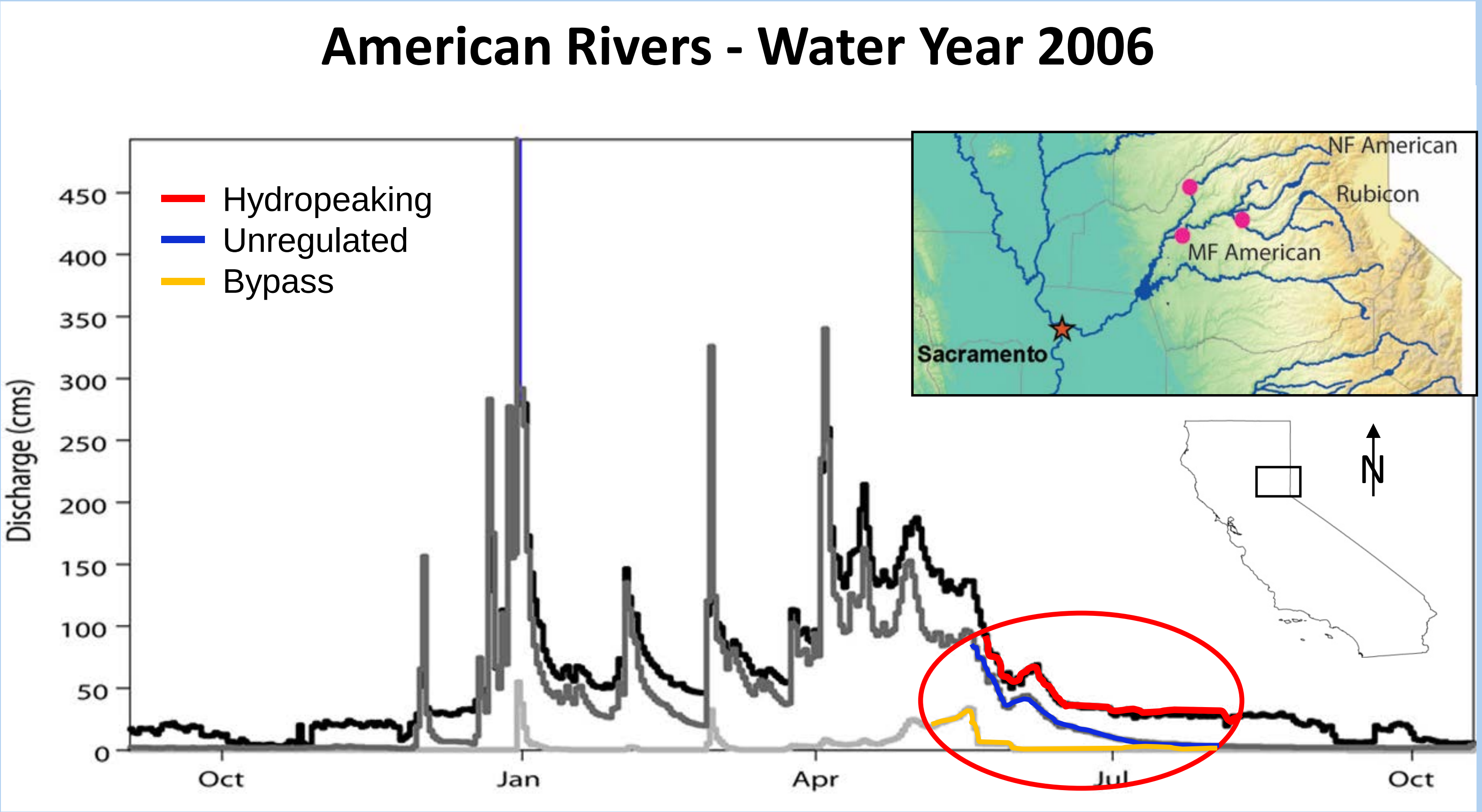
Food Web Duration



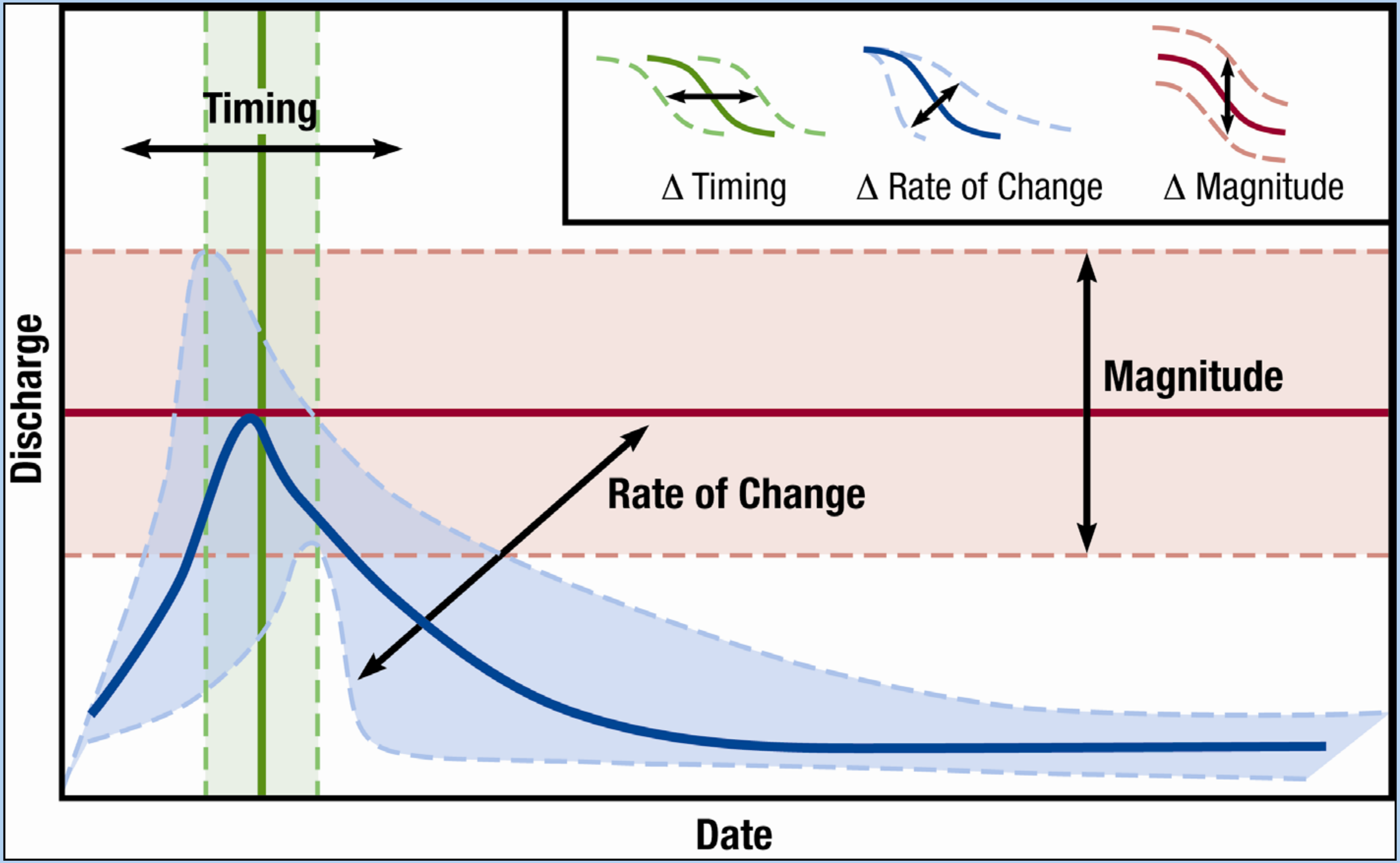
Percent Native Fish Leaving the Floodplain



Managed Flow Regimes

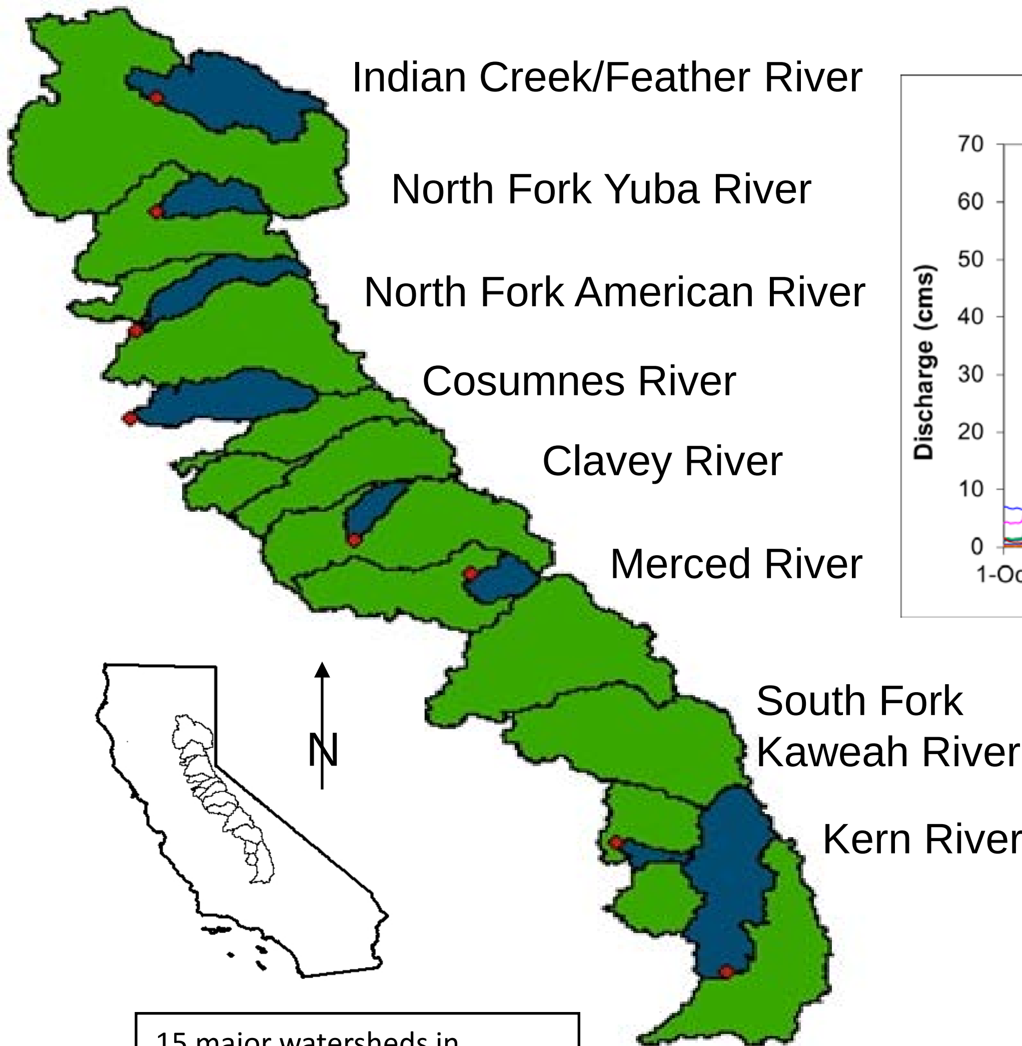


Quantifying the Spring Recession

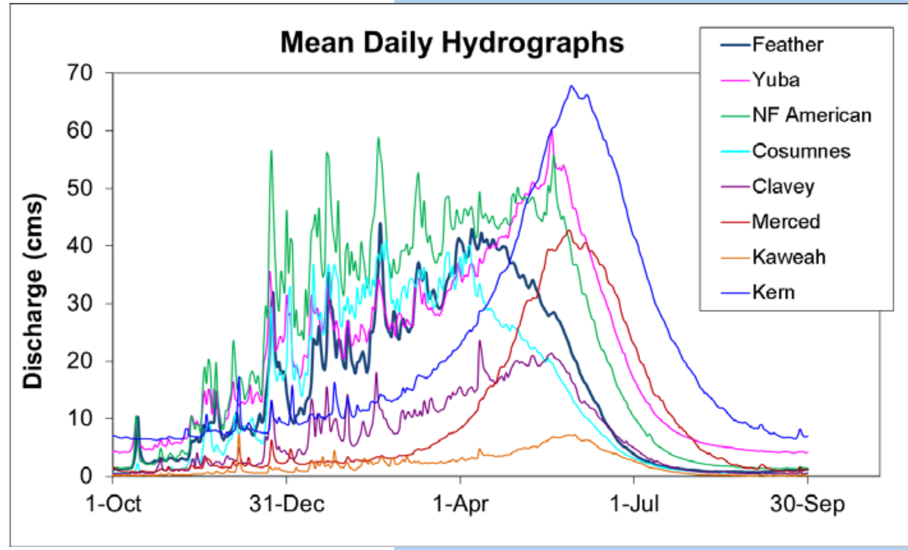


(Yarnell et al. 2010)

Unregulated Basins in California's Sierra Nevada mountains

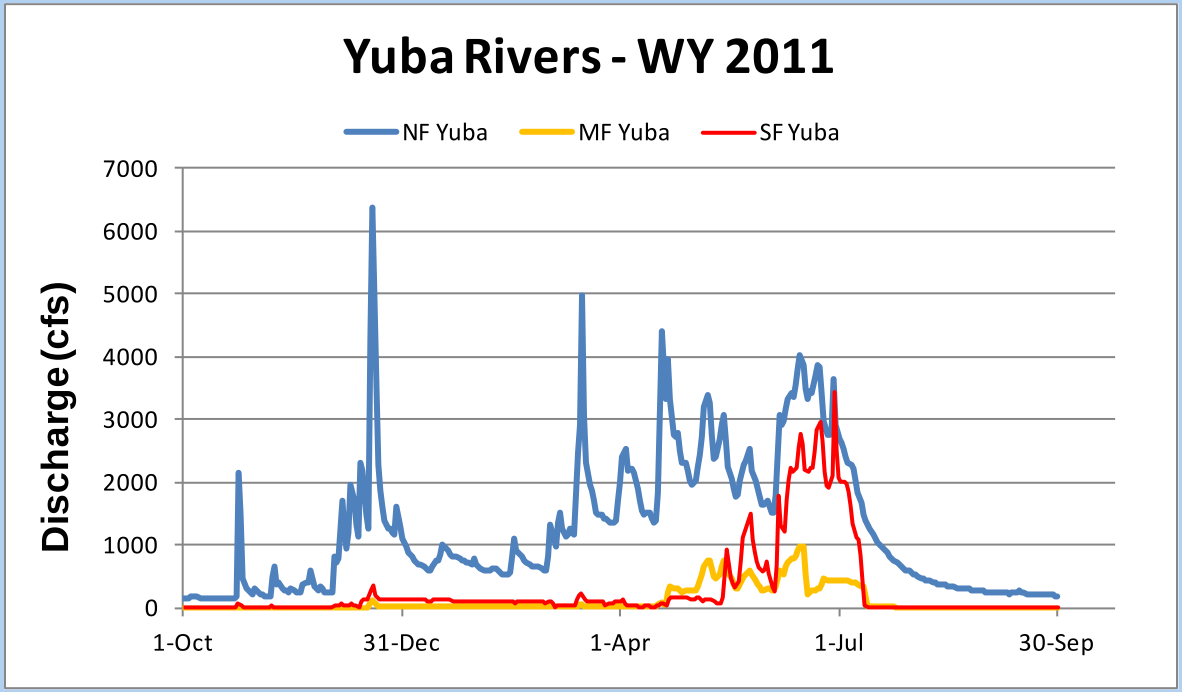


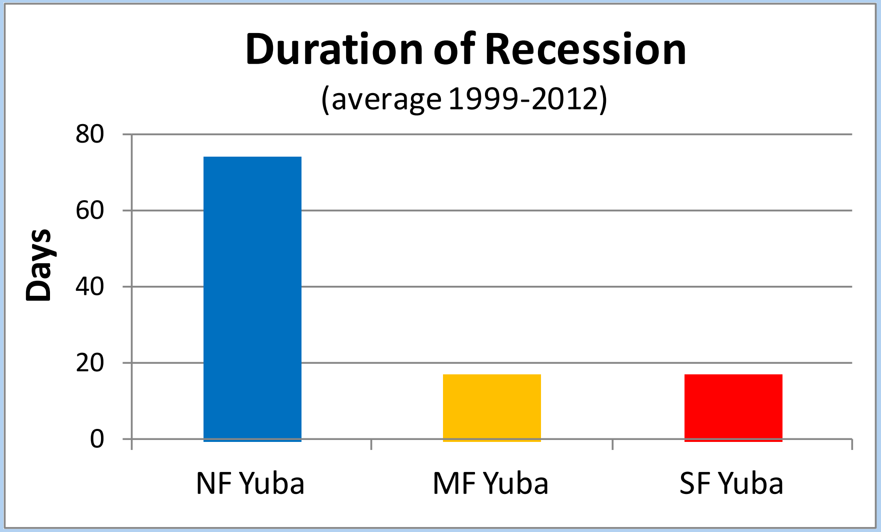
15 major watersheds in
The Sierra Nevada of California

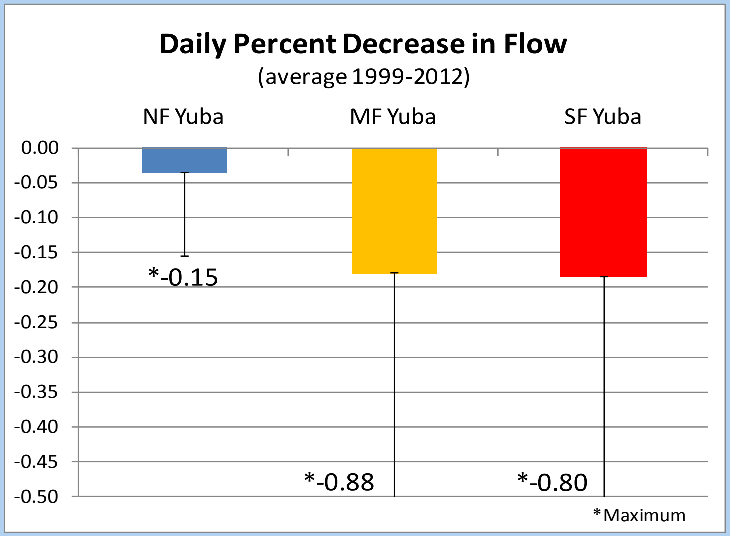


Daily recession rates:
1) are limited (< 25%),
2) decrease during the recession (8 – 4%)

Regulated versus Unregulated Flow Regimes

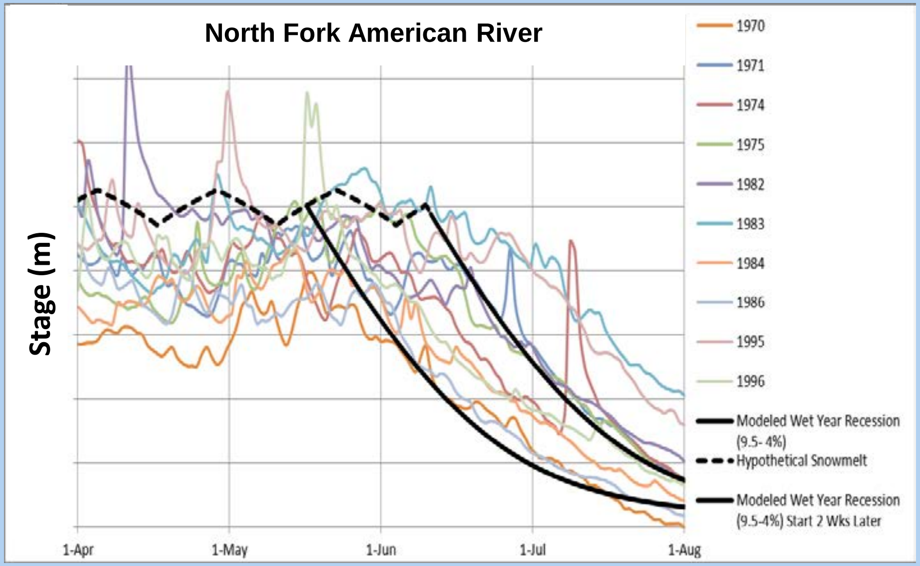




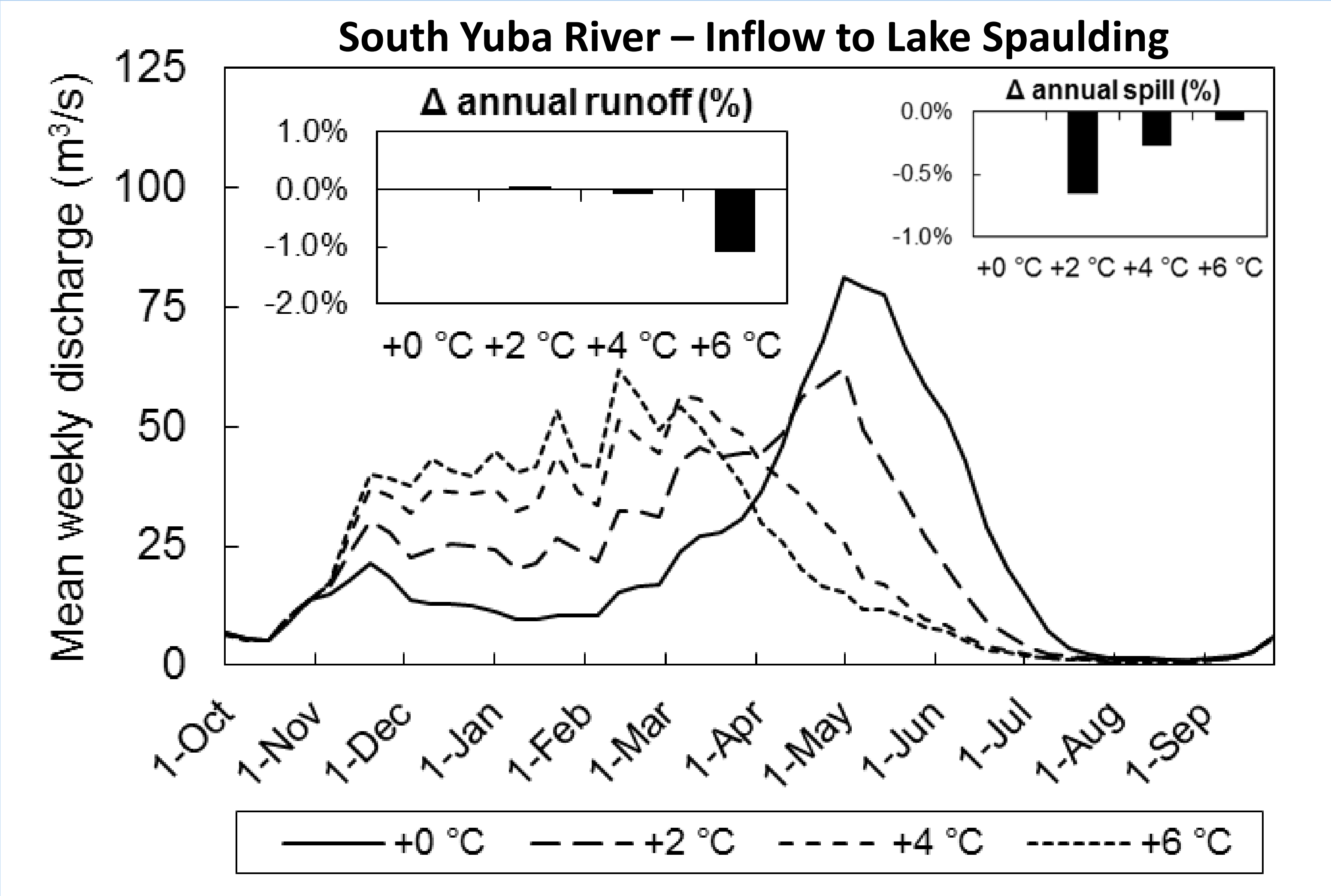


Modeling a Spring Recession in Regulated Systems

- Recession rates are consistent – can be modeled as downramping rates from spill or an ecological pulse
- Can be broadly applied in regulated systems:
  - Determine daily percent decrease
  - Determine a starting discharge
  - Determine down-ramp steps appropriate to infrastructure
- Examples in California:
  - South Fork San Joaquin River
  - McCloud River
  - Middle Fork American River
  - Upper Yuba Rivers

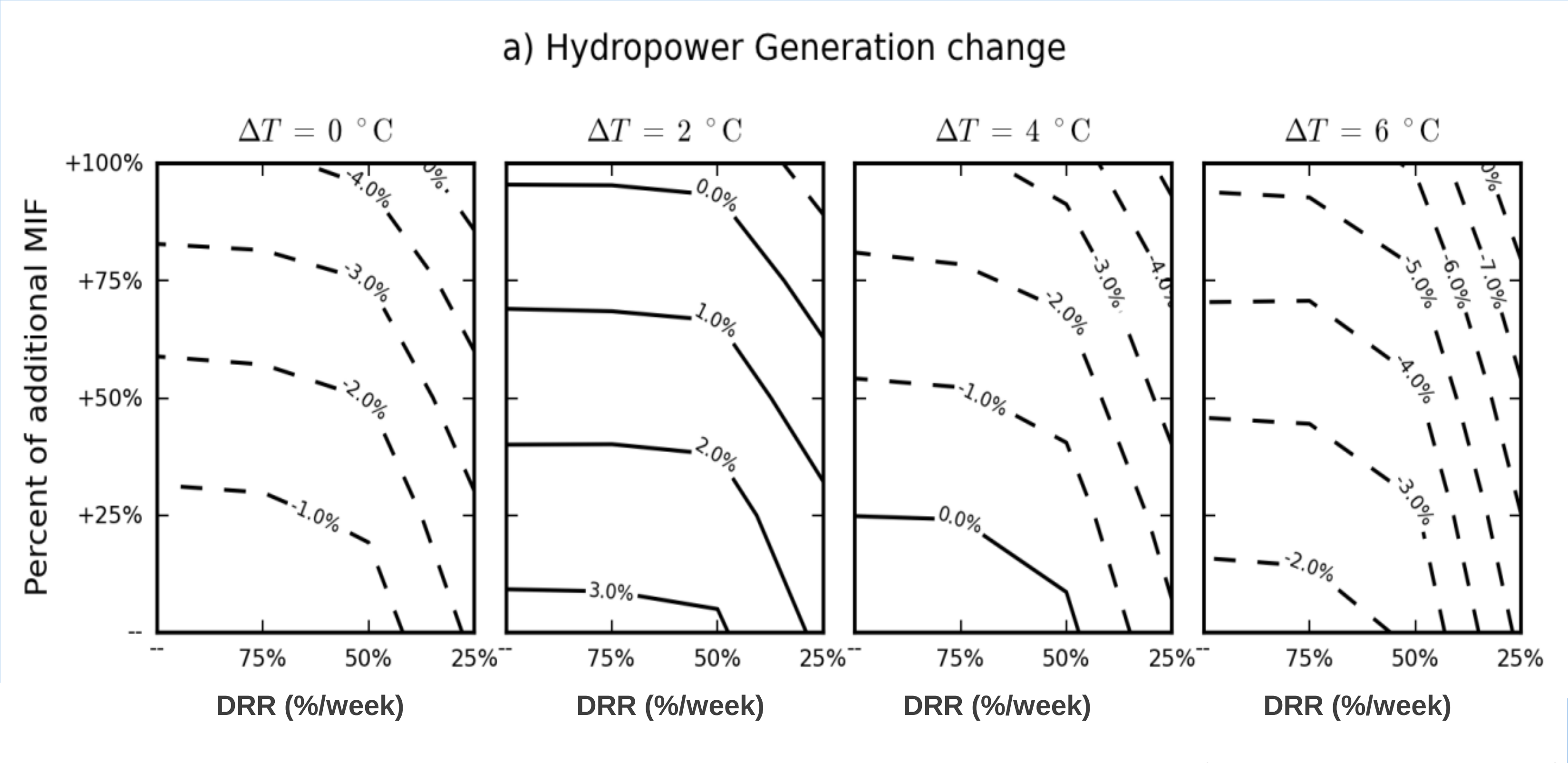


Climate Warming Scenarios – Sierra Nevada



(Rheinheimer, D.E., S.M. Yarnell and J.H. Viers. 2012. River Research and Applications. DOI: 10.1002/rra.2612)

Economic Trade-offs in Flow Management

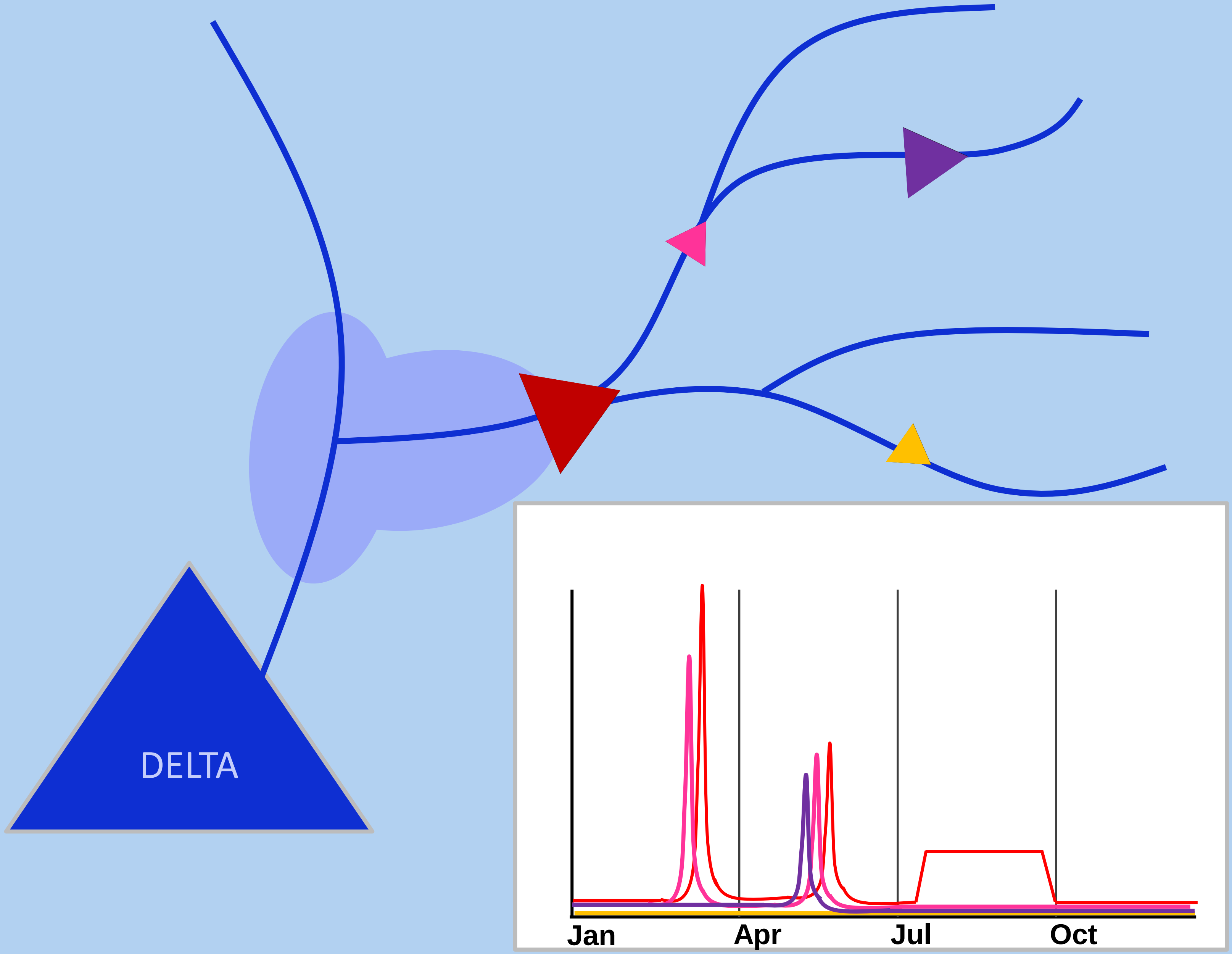


(Rheinheimer et al. 2012)

Environmental managers perspective – 25% ramp rate and 50% increase in flows costs only 3.5% loss in generation.

Operators perspective – 2% loss in generation acceptable, pick any combination on the curve.

Cumulative Effects Downstream



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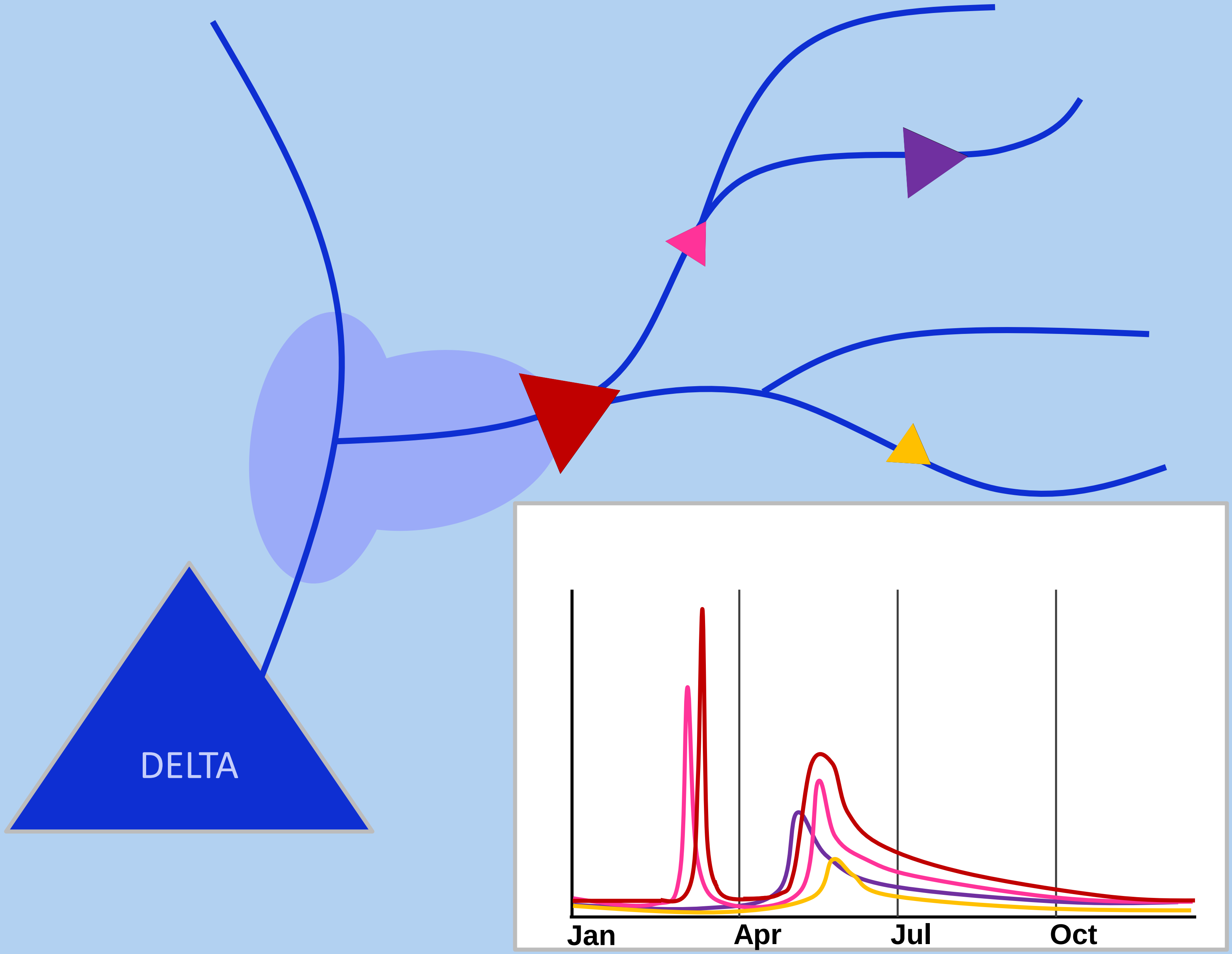
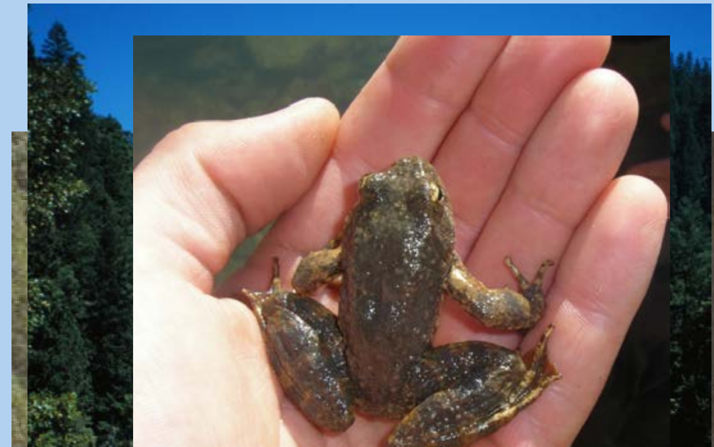


Conclusions

- Spring flow regimes provide key ecological cues for native species
- Spring recession flows are consistent, easily modeled, and manageable in regulated systems
- Coordinated management o upstream reservoirs can propagate to valley floodpla
- Using ecological functions observed in unregulated sys can be a guide for managem regulated systems



Aaron Fulton, 2005

Acknowledgements

- Funding: California Energy Commission, The Nature Conservancy, CA Dept of Fish and Wildlife
- Collaborators: US Forest Service